CIRCULAR POLARIZED TEXTILE ANTENNA

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To my honoured and esteemed family, friends and
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ABSTRACT

Recently, wearable electronic applications have arising in the commercial market. There has been growing use of textile antennas for wearable electronic and body centric applications such as healthcare, GPS and fire fighter personal communications. The use of circularly polarized antennas presents an attractive solution to achieve this polarization match which allows for more flexibility in the angle between transmitting and receiving antennas The new generation of textile has the capability to conduct electricity and at the same time as wearable. Microstrip patch antennas represent one family of compact antennas that offer a conformal nature and the capability of ready integration with communication system's printed circuitry. In this project, a circular polarized (CP) textile antenna is designed and simulated at 2.4GHz. To achieve circular polarization an inverted z slot asymmetrical structure is introduced at the center of radiating element, once incorporated onto the square patch two orthogonal components of electric field are excited with a 90^0 time phase difference. Both the patch and the inverted z slot were adjusted such that the wearable antenna generates the circular polarized wave at the resonance frequency. The proposed antenna has a dimension of 50mm x 50mm x 0.035mm, made by the use of fleece textile material as a substrate with a thickness 1mm, dielectric constant 1.3 and loss tangent 0.024. The antenna is fed via a subminiature version A (SMA) connector. The simulated and measured result shows that the antenna offers approximately 6.7% bandwidth (2.42GHz-2.59GHz) return loss, S_{11} is -32.16dB with impedance bandwidth of 167 MHz and The flexible antenna has axial ratio bandwidth of 80 MHz i.e 3.25% covering the frequency range of (2.42GHz - 2.5GHz). The antenna has a good performance in term of axial ratio.

ABSTRAK

Dewasa ini, aplikasi elektronik yang boleh dipakai telah meningkat di dalam pasaran komersial. Telah terdapat peningkatan di dalam penggunaan antenna tekstil untuk aplikasi elektronik boleh dipakai dan berteraskan badan seperti kesihatan, GPS dan alat komunikasi untuk anggota keselamatan. Kegunaan antena pengutuban bulatan memberikan penyelesaian yang baik untuk mendapatkan padanan pengutuban kerana ianya dapat memberikan sudut yang lebih fleksibel diantara antena pemancar dan penerima. Ciri tekstil yang terkini berupaya untuk mengalirkan arus elektrik disamping ciri asasnya untuk dipakai. Antena tampal jalur mikro adalah satu daripada kumpulan antenna kompak yang menawarkan sifat konformal dan kebolehupayaan untuk diintegrasikan dengan litar sistem komunikasi. Di dalam projek ini, antena yang boleh dipakai dengan pengutuban bulatan telah direkabentuk dan disimulasikan pada frekuensi 2.4 GHz. Untuk menghasilkan pengutuban bulatan ini, struktur slot tidak simetri berbentuk z terbalik telah diperkenalkan di posisi tengah elemen pemancar iaitu antena tampal berbentul segiempat. Ini menghasilkan dua medan elektrik komponen bersatah renjang yang berbeza fasa sebanyak 90 darjah. Antena tampal dan slot z terbalik disesuaikan supaya antena boleh dipakai ini menghasilkan gelombang pengutuban bulatan di frekuensi memancar. Antena yang dicadangkan ini berdimensi 50 mm x 50 mm x 0.035 mm, diperbuat menggunakan bahan tekstil fleece sebagai subtratum dengan ketebalan 1 mm, pemalar dielektrik 1.3 dan kehilangan tangen 0.024. Antena ini telah disuapkan menggunakan penyambung SMA. Keputusan simulasi dan pengukuran menunjukkan yang antena mempunyai lebar jalur kehilangan balikan (S11) iaitu 167 MHz (2.42 GHz – 2.59 GHz, 6.7 %), dengan nilai terendah S11 ialah -32.16 dB. Antenna bercirikan fleksibel ini mempunyai lebar jalur nisbah paksi sebanyak 80 MHz atau 3.25%, merangkumi julat frekuensi antara 2.42 GHz hingga 2.5 GHz. Antenna ini berprestasi baik terutama untuk keputusan nisbah paksi.

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LIST OF ABBREVIATIONS

WIFI	-	Wireless Fidelity
CP	-	Circular Polarization
WLAN	-	Wireless Local Area Network
GPS	-	Global Positioning System
LHCP	-	Left Hand Circular Polarization
RHCP	-	Right Hand Circular Polarization
dB	-	Decibel
CST	-	Computer Simulation Software
BW%	-	Bandwidth Percentage
BW	-	Bandwidth
GHz	-	Giga Hertz
mm	-	Millimeter
IEEE	-	Institute of Electrical and Electronic Engineers
RL	-	Return Loss
AR	-	Axial Ratio
BCWC	-	Body-Centric Wireless Communications
SMA	-	Subminiature Version A
RF	-	Radio Frequency

LIST OF SYMBOLS

L_P	-	Patch length
W_P	-	Patch width
W_S	-	Substrate width
L_S	-	Substrate length
L_{Slot}	-	Length of slot
W_{Slot}	-	Width of slot
F_o	-	Resonant frequency
λo	-	Free space wave length
λeff	-	Effective wavelength
$\mathcal{E}r$	-	Substrate dielectric constant
$\mathcal{E}eff$	-	Effective substrate dielectric constant
C	-	Speed of light

CHAPTER 1

INTRODUCTION

1.1 Introduction

Wearable antenna investigation now a days that focus on body worn application is rapidly growing, which provide a tremendous range of application such as fire fighter, health care and body centric communication. microstrip antennas is one of the most commonly used antennas in applications which required Circular polarization, regardless of receiver orientation the antenna would be able to received a component of signal, Circular polarization (CP) microstrip antennas are getting more attention in modern mobile wireless communications, in mobile and portable wireless application where wireless devices frequently change their location and orientation it is nearly impossible to constantly match the spatial orientation of the devices. Circularly polarized antennas could be matched in wide range of orientations because the radiated waves oscillate in a circle that is perpendicular to the direction of propagation [1-3]. To achieve this polarization matching the transmitter and the receiver should have the same axial ratio, spatial orientation and the same sense of polarization. This project is concerned with the design of a circularly polarized microstrip antenna that would operate in the 2.4 GHz range. This range is commonly used by wireless local area devices and wireless personal area devices such as the 802.11 WIFI and the 802.15.4 Zigbee wireless systems. [13]

Designing a circularly polarized microstrip antenna is challenging; it requires combination of design steps. The first step involves designing an antenna to operate at a given frequency. In the second step circular polarization is achieved by either introducing a perturbation segment to a basic single fed microstrip antenna, or by feeding the antenna with dual feeds equal in magnitude but having 90° physical phase shift. The shape and the dimensions of the perturbation have to be optimized to ensure that the antenna achieves an axial ratio that is below 3 dB at the desired design frequency. However for wider angles it is difficult to maintain the orthogonality of these components. For microstrip patch antennas, which are very convenient due to easy manufacturability, the ground plane attenuates the electric component parallel to it, degrading the axial ratio. So far proposed omnidirectional CP antennas usually either use multiple radiators or complex polarisers. Neither of these solutions are convenient for applications on small portable devices. Compact and easy to manufacture omnidirectional CP antennas could have many applications. [11-14]

The main advantage of CP is that regardless of receiver orientation, it will receive a component of signal. However, CP can be archived using single element or arrays of microstrip antenna. [7]

Figure 1.1 below shows the schematic of simple patch microstrip antenna. Which consist of ground plane, dielectric substrate and the radiating element.

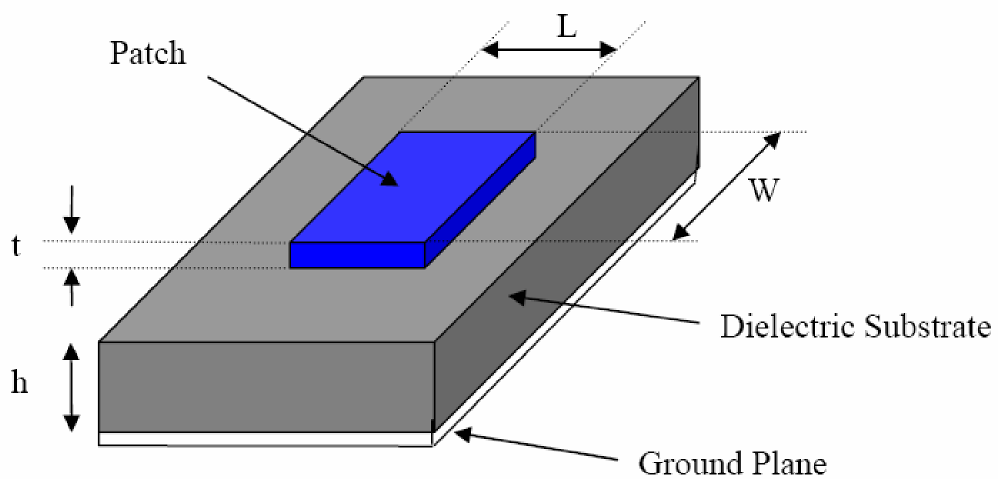

Figure1.1: Schematic of a simple patch microstrip antenna

1.2 Project Background

The investigation on wearable devices which focus on body-worn communication is rapidly growing, the interest in implementing textile technology as a wearable antenna for body worn communication has gained huge attention since the fabric material does not force the wearer to abandon the comfort zone The wearable electronic devices are such devices worn by a person as un obstructively as clothing to provide intelligent assistance. The key considerations for wearable electronics are to be robust, flexible, small size, consume a small amount of power, and comfortable to wear.[8]

Modern technology requires the antenna in more compact and also applicable for body worn application in which Textile material forms interesting substrate because fabric antenna can be easily integrated into clothes with low profile and ease of fabrication. The applications of wireless communication such as Global positioning systems (GPS), WLAN, satellite communication require more bandwidth due to integration of various services in single receiver [10].

In order to achieve circular polarization using only a single feed, two modes should be exited with equal amplitude and 90° out of phase. Since basic microstrip antenna shapes produce linear polarization there must be some deviation in the patch design to produce circular polarization. Perturbation segments are used to split the field into two orthogonal modes with equal magnitude and 90° phase shift. Therefore the circular polarization requirements are met. To generate circular polarization, two orthogonal components of electric field are needed. These components need to be equal in amplitude, but shifted in phase by 90°. CP antennas are demanding to design, however offer multiple benefits. [11-13]

This project achieves circular polarization by introducing a perturbation in the form of inverted z slot to the patch antenna. Truncated edges have been used to achieve circular polarization in square, elliptical and circular patch in [4-6]. The work in [6] used a single feeding and did not provide details about the parametric optimization of this antenna. Dual feeding is not suitable for microstrip patch since it requires power divider, complexity and not easy to matched. [10]

Coaxial feeding techniques are commonly used because they are simple, easy to manufacture, low in cost, can be located anywhere in the patch and compact in structure. Single fed circularly polarized microstrip antennas are considered to be one of the simplest antennas that can produce circular polarization [7]. In order to achieve circular polarization using only a single feed, two modes should be exited with equal amplitude and 90° out of phase. Since basic microstrip antenna shapes produce linear polarization there must be some deviation in the patch design to produce circular polarization. Perturbation segments are used to split the field into two orthogonal modes with equal magnitude and 90° phase shift. Therefore the circular polarization requirements are met. [13]

1.3 Problem Statement

Recently, wearable electronic applications have arising in the commercial market. There has been growing use of textile antennas for wearable electronic and body centric applications such as healthcare, GPS and fire fighter personal communications.

Therefore, by using fabric as the substrate and the limitation of the transmitter-to-receiver orientation can be effectively solved when antennas with circular polarization (CP) are utilized every person who is using wired technology device can easily move around while doing their job. The person can wear the wearable device onto their cloth. So, the problems of limited movements are considered solved.

1.4 Objectives of the work

The objectives of this research are as follows:

To design, simulate a circular polarized antenna at 2.4GHz using microstrip Technique.

To fabricate the antenna on fleece textile substrate.

To compare the simulated and measured result i.e. axial ratio, return loss and Radiation pattern are in good agreement.

1.5 Scope of Work

The project is restricted within the below limitations:

i. Design and simulate a circular polarized textile antenna.
ii. Utilizing fleece material as substrate to design the antenna.
iii. Analyze the simulated result using CST Microwave Studio in terms of antenna properties such as return loss, radiation pattern and axial ratio.
iv. Fabrication and measurement of the antenna and comparison between simulation and measurement.

1.6 Organization of the Project

This thesis is divided into five chapters. Each chapter will discuss on the different issues related to this project. Following are the outlines of the project for each chapter.

Chapter 1: covered the introduction and overview of the project background, problem statement, objective, and scope of work of this project. All of the data should be stated clearly before designing the antenna.

Chapter 2: A literature review on previous works focusing circular polarized textile antenna to get clear view of the title project.

Chapter 3: explained the flowchart and the methodology that will be done to finish the project successfully. The design specification which includes the fleece fabric as a substrate is presented in this chapter.

Chapter 4: presents the results and discussion of the project. Simulated and measured results for return loss, radiation patterns and axial ratio are analyzed.

Chapter 5: gives the summarized works and conclusion for the overall of the project. Besides, future works and recommendations to improve the performance of the designed antenna are also stated.

1.7 Summary

In this chapter, the overview of circular polarized textile antenna, problem statement, the objective of this project, and scope of project are all stated clearly.

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